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GB-A-2 006 508

Patents Abstracts of Japan,vol.6,no.60,April 17,1982,(E-102)(938),& JP,A,571215,06-01-1982

IEEE TRANSACTIONS ON MAGNETICS,vol.Mag-17,no.6,November 1981,pages 3175-3177;IEEE,New York,US,S.KADOKURA et al.:Deposition of Co-Cr films for perpendicular magnetic recording by improved opposing targets sputtering

JOURNAL OF CRYSTAL GROWTH,no.45,1978,pages 361-364,M.NAOE et al.:"High rate deposition of magnetic films by sputtering from two facing targets."

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Description

The present invention relates to a perpendicular magnetic recording medium comprising a nonmagnetic base and two magnetic layers formed successively on said nonmagnetic base, said two magnetic layers consisting of a first layer of a low-coercive force material and a second layer of a cobalt alloy which has a direction of easy magnetization perpendicular to the surface of the recording medium and to a method for producing the same.

The present magnetic recording systems fundamentally use the longitudinal (in-plane) magnetization mode, that is, a magnetization being parallel to the base, to which the cobalt alloy is applied.

Iwasaki has proposed in IEEE Transactions on Magnetics, Vol. MAG-16, No. 1, January 1980, pages 71 to 76 a perpendicular magnetic recording system which theoretically makes it possible to produce a higher recording density than one produced by using the longitudinal magnetization mode. In the perpendicular magnetic recording system, the magnetization perpendicular to the surface of the magnetic recording layer is used for recording.

The magnetic layer adapted to the perpendicular magnetization system should be an alloy layer mainly consisting of cobalt and additionally chromium and should have a magnetic anisotropy perpendicular to the layer surface. This magnetic anisotropy, i.e., perpendicular magnetic anisotropy, should usually have the relationship $Hk \geqq 4\pi Ms$, wherein Hk and $4\pi Ms$ are the anisotrophy field and the maximum demagnetizing field of a magnetic layer, respectively. This relationship designates that the magnetic layer possesses a satisfactorily high perpendicular anisotropy.

In the alloy layer mentioned above, the direction of easy magnetization, i.e., the C axis of the hexagonal cobalt alloy, is oriented perpendicular to the layer surface. Such orientation is referred to as perpendicular orientation and is evaluated by subjecting a magnetic film to X-ray diffraction, obtaining the rocking curve of the diffraction peak from the (002) plane of the hexagonal closed packing (hcp) structure, and measuring the half value width $\Delta\theta_{50}$ of the rocking curve. A half-value width $\Delta\theta_{50}$ of 10° or less is alleged to be sufficient for obtaining excellent perpendicular anisotropy. The coercive force H_{cv} in the perpendicular direction, which is more than 8 kA/m (100 Oersted (Oe)), is allegedly sufficient for obtaining an excellent perpendicular orientation.

US—A—4,219,946 proposes a perpendicular magnetic recording medium (hereinafter referred to as a two-layer film) which is suitable for effectively recording and/or regenerating signals from a single-pole-type magnetic recording head. More specifically, US—A—4,210,946 discloses a layer of low coercive force material consisting of Permalloy and a layer of a 5% to 25% by weight of chromium-cobalt alloy successively deposited on a nonmagnetic base by means of an RF sputtering method, the target electrode and the base being disposed opposite to one another. The two-layer film disclosed in US—A—4,210,946 allegedly provides a high recording density and a high output.

It is known that the half-value width $\Delta\theta_{50}$ of a cobalt alloy is increased and the perpendicular magnetic anisotropy is deteriorated more than Permalloy**) is used for the layer of low coercive force material, as compared with the half value width of a perpendicular magnetic recording medium which does not comprise a layer of low coercive force material.*) This perpendicular magnetic recording medium is hereinafter referred to as a one-layer film. In the RF sputtering method used in US—A—4,210,946, it is necessary to use as the nonmagnetic base an expensive heat-resistant macromolecular material film, such as a polyimide film, because the temperature of the nonmagnetic base is increased during RF sputtering. If an inexpensive macromolecular material film, such as a polyester film, is used as the nonmagnetic base, the deposition rate film is decreased and the RF sputtering device must be provided with a specified cooling means. An RF sputtering method cannot be applied in the large-scale production of or high-speed growth of perpendicular magnetic recording mediums because the highest growth rate of a cobalt alloy layer which can be achieved at present by means of the RF sputtering method is about 50 nm (500 Å) per minute even when a polyimide film is used as the nonmagnetic base. In addition, since the one-layer film or two-layer film obtained by means of the RF sputtering method exhibits a poor flexibility, it may cause the magnetic head to wear or may be damaged by the magnetic head when used for recording or regenerating signals.

It is an object of the present invention to provide a two-layer film in which the perpendicular orientation is not reduced due to the layer of low coercive-force material.

This object according to the invention is accomplished by means of a recording medium of the type indicated at the outset and being characterized in that said first layer of low-coercive material consists of an alloy which is mainly composed of cobalt and additionally of tantalum, and said second cobalt alloy layer has a composition different from said first layer of a low-coercive material.

It is another object of the present invention to provide a method for producing a two-layer film at such an enhanced rate of production as to make the method commercially applicable. The method should make it possible to use a less expensive and a low heat-resistant film, such as a polyester film, as the nonmagnetic base of the two-layer film.

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*)(Uesaka et al, Technical Report S. 7-1, "Two-Layer Films for Perpendicular Recording Medium).

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This object is accomplish d by the method of claim 8.

Thus, in accordance with the objects of the present invention, there is provided a perpendicular magnetic recording medium (a two-layer film) comprising a nonmagnetic base and two magnetic layers successively formed on the nonmagnetic base, i.e., a layer of low coercive-force material and a layer of a cobalt alloy and having a direction of easy magnetization in a direction perpendicular to the film surface, characterized in that the layer of low coercive-force material consists of an alloy which is mainly composed of cobalt and additionally tantalum.

Further, the two-layer film according to the present invention in a manner corresponding to US—A—4,210,946 has a two-layer structure and is characterized by using as the layer of low coercive-force material an alloy (hereinafter referred to as a Co-Ta alloy) which is mainly composed of cobalt and additionally contains tantalum. This alloy can provide a cobalt alloy (hereinafter referred to as a Co-Cr alloy) layer having a very improved perpendicular orientation, which in turn leads to provide the two-layer film having a high recording density. In the perpendicular magnetic recording technique, to attain a high recording density, it is important that the perpendicular coercive force H_{cv} of the perpendicular magnetic recording medium matches the magnetic characteristics of the recording and/or regenerating head. In accordance with the characteristics of a magnetic recording system to which the perpendicular magnetic recording medium is applied, the perpendicular coercive force H_{cv} is determined within the range of from 16 to 104 kA/m (200 to 1300 Oe). In determining the perpendicular coercive force H_{cv}, it is crucial that th magnetic anisotropy of the Co-Cr alloy layer in terms of the half-value width $\Delta\theta_{50}$ be excellent. The perpendicular magnetic anisotropy of the two-layer film of the present invention is very excellent and is surprisingly superior to that of a one-layer film. The reason why such an excellent perpendicular magnetic anisotropy can be obtained is not clear but appears to be as follows.

When there is only a trace of Ta in the Co-Ta alloy layer the most energentically stable Co crystals are those which are oriented perpendicular to the surface of the Co-Ta alloy layer, and in which the distance between the C planes of hcp crystals are enlarged due to Ta atoms. When the Co-Cr alloy is deposited on the surface of the Co-Ta alloy layer contain only a trace of Ta, mismatching of the crystal lattices occurs locally between the Co-Ta alloy layer and the Co-Cr alloy layer because the lattice constants of these two alloys are slightly different from one another. In this case, the perpendicular orientation of the Co-Cr alloy is low.

When the Ta concentration of the Co-Ta alloy layer is high, the Co atoms in the Co-Ta alloy becomes disarranged as compared with that of the hcp crystals, that is, disordering of the Co atoms takes place. Since the Co-Ta alloy tends to exhibit unclear grain boundaries in proportion to the degree of disordering of the Co atoms, the Co-Ta alloy layer is uniform when observed microscopically. Such uniformity results in a smooth Co-Ta alloy layer surface as well as in the elimination of local mismatching between the Co-Cr alloy crystals and the Co-Ta crystals. When the Co-Cr alloy is deposited on the uniform and smooth Co-Ta alloy layer, Co-atoms of these layers are brought into contact with each other at the beginning of deposition, and during deposition the Co crystals grow perpendicularly and form crystal lattices which are oriented perpendicular to the film surface.

As indicated above in accordance with the objects of the present invention, there is also provided a method for producing a perpendicular magnetic recording medium (two layer film), comprising the steps of: forming a said Co-Ta alloy layer by sputtering method (hereinafter referred to as an opposed target sputtering method), wherein a magnetic field is generated in a direction perpendicular to the surfaces of a pair of targets arranged opposite to one another within a sputtering device, and said cobalt alloy layer is deposited on the base, which is located beside a space between said pair of targets and which faces said space; and, forming said cobalt alloy layer by the opposing target sputtering method.

Embodiments of the present invention are described hereinafter.

According to one embodiment, the Ta concentration of the Co-Ta alloy is at least 15% by weight or at least 5.4 atomic %. In this case, the coercive force in plane H_c of the Co-Ta alloy is very low, e.g., 8 kA/m (100 Oe) at the highest. Furthermore, the Co-Cr alloy layer on the Co-Ta layer has a half-value width $\Delta\theta_{50}$ of ten degrees or less.

According to another embodiment of the present invention, the Co-Ta alloy, i.e., the layer of low coercive-force material alloy, is amorphous. An amorphous Co-Ta alloy exhibits no magnetic anisotropy. That is, an amorphous Cp-Ta alloy has no magnetic anisotropy imparted to it by its crystal structure. In addition, an amorphous Co-Ta alloy exhibits a very low coercive force in plane H_c of, for example, 0.4 kA/m (5 Oe) or less, a very low half-value width $\Delta\theta_{50}$ of four degrees or less, a high permeability, and a high resistivity. The two-layer film, in which th Co-Ta layer is amorphous and thus exhibits the above-described properties, is very effective for enhancing the recording sensitivity when it is used for high-density and high-speed r cording. A conventional lay r of low co rcive-force mat rial, i.e., crystalline material, such as permalloy, has a magnetic anisotropy which results in a reduction in permeability and an increase in watt loss, including hysteresis loss and eddy-current loss. Therefore, when a conventional two-film layer comprising a Permalloy layer is used for high-density recording, the S/N ratio is disadvantageously low. This disadvantage can be eliminated by using the amorphous Co-Ta alloy layer of the present invention.

In addition, since the amorphous Co-Ta alloy of the present invention exhibits the abov -described properties, the layer of low coercive-force material can be made very thin, which is advantageous from an

Co-Ta alloy is high. It is therefore possible to attain magnetic characteristics which is thermally stable. Furthermore, the amorphous Co-Ta alloy is highly corrosion-resistant and is therefore advantageous for practical use.

According to an embodiment of the present invention, the Co concentration of the Co-Ta alloy is at least 50% by weight (24.6 atomic %), (24 wt-%). Preferably, the Co concentration of the Co-Ta alloy is virtually the same as that of the Co-Cr alloy. According to this embodiment, the interface between the Co-Ta alloy layer and the Co-Cr alloy layer is mechanically very stable because both of the layers have expansion coefficients and specific heats which are commensurated to each other and further because the wettability between the layers is good. In addition, a solid solution may form at the interface between the Co-Ta alloy and the Co-Cr alloy.

A conventional layer of low coercive-force material, e.g., an iron-based alloy, such as Permalloy, is liable to oxidize or undergo deterioration of its properties during the formation thereof.

According to another embodiment, the Co-Cr alloy contains from 10% to 25% by weight of Cr and may contain an additional element or elements, such as W, Mo, Ru, Pt, Os, Ni, Re, Ta, or the like. The concentration of the additional element or elements must be such that the known perpendicular magnetic anisotrophy induced due to C-axis orientation in the hcp crystals is not impaired. Preferably, Ta is contained in the Co-Cr alloy at a concentration of from 2 to 10 atomic %, with the provision that sum of Ta and Cr concentration is 27 atomic % at the highest.

According to yet another embodiment, the nonmagnetic base consists of a polyimide film or, preferably, a polyester film.

The preferred embodiments of the present invention are hereinafter described with reference to the drawings, wherein:

Figure 1 is a sputtering device used for implementing the method of the present invention;

Figure 2 is a target used for forming a Co-Ta alloy layer;

Figure 4 is a means for holding a nonmagnetic base;

Figures 3, 5 and 6 are graphs illustrating the experimental results obtained in Example 1;

Figures 7 and 8 illustrate a further embodiment of a sputtering device;

Figure 9 is a partial view of Figure 7;

Figure 10 illustrates the arrangement of magnets in a target;

Figures 11 through 13 illustrates sputtering devices which can be used for implementing the method of present invention; and

Figures 14 and 15 are drawings illustrating the magnetic flux density and erosion of a target, respectively.

Referring to Figure 1, a sputtering device with a pair of opposed targets is illustrated. This sputtering device, with a pair of opposed targets, which is used to prepare films made of perpendicular-oriented materials is disclosed in EP—A—0054269.

The sputtering device with a pair of opposing targets is hereinafter simply referred to as opposed targets sputtering device. The device comprises a vacuum vessel 10 and a pair of targets T_1, T_2 which are closely attached or secured to the target holders 15, 16. The targets T_1, T_2 are arranged opposite to one another so that their surfaces, which are subjected to sputtering, i.e., the sputtering surfaces T_{1S}, T_{2S}, face one another over the space between the targets T_1, T_2 which are parallel to one another.

The target holders 15, 16 are secured to the side plates 11, 12 of the vacuum vessel 10 via the insulating members 13, 14. The targets T_1, T_2, as well as the permanent magnets 152, 162, are cooled by water, which is admitted into the target holders 15, 16 via the cooling conduits 151, 161. The permanent magnets 152, 162 are means for generating a magnetic field perpendicular to the sputtering surfaces T_{1S}, T_{2S} and are arranged in such a manner that the N pole of one of the permanent magnets faces the S pole of the other permanent magnet. A magnetic field is generated only between the targets T_1, T_2. The target holders 15, 16 and the insulating members 13, 14 are protected by the shields 17, 18 from plasma particles formed during sputtering. The shields 17, 18 prevents an abnormal electric discharge to occur at places other than the targets T_1, T_2.

The nonmagnetic base 40 on which the magnetic layers are formed by opposed target sputtering method is located on the base holder 41 disposed beside the targets T_1, T_2 so that the nonmagnetic base 40 is located beside the space between the targets T_1, T_2 and faces this space. The base holder 41 is usually positioned perpendicular to the sputtering surfaces T_{1S}, T_{2S}.

Reference numeral 50 denotes a sputtering power source, which is a direct current source to which the targets T_1, T_2 and a ground terminal are connected as a cathode and an anode, respectively. The sputtering power is applied between the targets T_1, T_2 and the grounded vacuum vessel.

A retractable shutter (not shown) is disposed between the nonmagnetic base 40 and the targets T_1, T_2 so as to protect the nonmagnetic base 40 from plasma during the pre-sputtering period. The vacuum vessel 10 is provided with a gas-exhaust port which communicates with a gas-exhaust system 20 and a gas-intake port which communicates with a gas source 30.

When operating the opposed-targets sputtering device described above, the gas exhaust system 20 is preliminarily operated so as to satisfactorily withdraw the gas in the vacuum vessel 10 through the gas exhaust port, and, subsequently, a sputtering gas, such as an argon gas, is admitted into the vacuum vessel

for xample, from 13.3 to 0.13 Pa (10^{-10} to 10^{-4} Torr).

In the opposed targets sputtering device shown in Figure 1, the magnetic field H is perpendicular to the sputtering surfaces T_{1S}, T_{2S}. Due to the layout and configuration of the targets T_1, T_2, high-speed sputtering at a low temperature can be realized. That is, the ionized sputtering gas and gamma electrons which are expelled from the sputtered targets are confined in the space between the targets T_1, T_2, with the result that high-density plasma is formed between the targets T_1, T_2. It is believed that high-speed growth of the magnetic layers can be achieved by confinement of the high-density plasma. Since the nonmagnetic base is offset from the targets T_1, T_2, heat generation due to the impinging effects of the electrons on the nonmagnetic base 40 is not appreciable and therefore magnetic layers can be formed at a low temperature.

Referring to Figure 2, a preferred embodiment of a target is illustrated. The surface of the target is divided into eight fan-shaped zones. The fan-shaped zones II (Ta) consist of 100% Ta and the fan-shaped zones I (Co) consists of 100% Co. The Ta concentration of the Co-Ta alloy can be adjusted by determining the proportion of the surface area of the former zones to that of the latter zones.

The opposed-targets sputtering device shown in Figures 7 and 8 comprises the vacuum vessel 410. The vacuum vessel 410 is provided with a gas-exhaust port 440 and a gas-intake port 450 which are connected to the not-shown gas-exhaust system and to the gas source not shown, respectively.

The opposed-targets sputtering device is provided with a plurality of pairs of opposed targets which are arranged in rows and which realize multi-stage sputtering. More specifically, such plurality of pairs consists of the first pair (T_1) of targets T_{A1} and T_{B1} and the second pair (T_2) of targets T_{A2} and T_{B2}. The target holders 411, 412, and 413, are secured to the side walls 410A and 410B (Figure 8) of the vacuum vessel 410 and are spaced at a predetermined distance therebetween. The first pair (T_1) and second pair (T_2) are therefore arranged in a row. The targets T_{A1} and T_{A2} are secured to a single target holder, i.e., the target holder 412. The target holders 411, 412, and 413 are nonmagnetic and hollow, and the conduits 411A, 412A, and 413A for water cooling are inserted into the hollow spaces thereof. That is, holding and cooling of the targets T_{A1}, T_{A2}, T_{B1}, and T_{B2} are achieved by a rather compact means.

The permanent magnets are denoted by 442, 443, and 444 and are arranged so as to generate a magnetic field only between the opposed targets and which is directed perpendicular to the surface of the targets. Since each permanent magnet has a cylindrical shape, the magnetic field (not shown) is generated in the form of a cylindrical wall between the opposed targets. Magnetic field-generating means, such as the permanent magnets 442, 443, 444, are located behind the targets T_{A1}, T_{A2}, T_{B1}, T_{B2} and the polarities of all of the permanent magnets are preferably oriented in the same direction, as is shown in Figure 7. A pair of targets T_{B1} and T_{A2}, which are arranged in a portion other than the end portions of the vacuum vessel, is provided with a common magnetic field-generating means, i.e., the permanent magnet 443, and is secured to both ends of a common target holder, i.e., target holder 412.

A nonmagnetic base-conveying means 470 (Figure 7) is adaptable for conveying a long, flexible strip of macromolecular material. More specifically, the nonmagnetic base-conveying means 470 comprises a reel 480, from which the nonmagnetic base 420 (Figure 7) is uncoiled, and rotatable conveying rollers 418U, 482U, 483U, 481D, 482D, and 483D which define a U-shaped conveying pass of the nonmagnetic base 420, and a coiler 490 which coils the nonmagnetic base 420 at a predetermined speed. The rotatable tensioning rollers 491U, 482U, 483U, 481D, 482D, and 493D are secured to the side walls 410A and 410B (only th rotatable tensioning rollers 481D and 493D are shown in Figure 8). These rotatable tensioning rollers are arranged so that the nonmagnetic base 420 successively passes the upper and lower ends of the spaces S_1 and S_2 between the opposed targets T_{A1}, T_{A2}. T_{B1}, and T_{B2}. The nonmagnetic base-supporting plates 421U, 422U, 421D, and 422D are arranged beside the above-mentioned upper and lower sides of the spaces S_1+S_2, and when the nonmagnetic base 420 slides on the plates, it may be heated or cooled by heating or cooling equipment (not shown) installed behind the plates. The heating means may be an electric heater or a heating-medium circulating means. The cooling means may be a cooling-medium circulating means. Rotatable tensioning rollers 491U, 482U, 483U, 484U, 481D, 482D, 493D, and 484D are arranged in front of and behind the nonmagnetic base-supporting plates 421U, 422U, 421D, and 422D so as to bring the nonmagnetic base 420 into a tight contact with the supporting plates when the nonmagnetic base 420 is being conveyed. Shields are denoted by 446, 447 and 448 and surround the target holders 411, 412, and 413. The opposed-targets sputtering device is provided with the power sources 459, and 461.

The first and second pairs T_1 and T_2 of targets may comprise targets having the same composition. In this case, the deposition rate of a magnetic film can be four times as high as that attained by the opposed-targets sputtering device shown in Figure 1.

The nonmagnetic base 420 is subjected to the deposition of a magnetic film on both the upper and the lower ends of the spaces S_1 and S_2. As a result, the rate deposition of the magnetic film per one pair of opposed targets is twice as high as that attained in the opposed-targets sputtering device shown in Figure 1.

Referring to Figure 9, the nonmagnetic base-supporting plate 421D is illustrated. The nonmagnetic base-supporting plate 421D is lectrically insulated from the vacuum vessel (not shown) and is l ctrically connected to the power sources B_1, B_2 and B_3. The nonmagnetic base-supporting plate 421D is separat d by the electrically insulating bodies I into three electrode sections E_1, E_2, and E_3, which are connected to the power source B_1, B_2, and B_3, respectively. A bias potential det rmined by each of the power source B_1, B_2,

impact energy of the gamma electrons and the like when they are deposited on the nonmagnetic base 420. On the other hand, a positive bias potential increases the impact energy of the gamma electrons and the like when they are deposited on the nonmagnetic base 420. Since the kinetic energy of the gamma electrons and the like is not uniform within the space between the targets T_{A1} and T_{B1}, the rate deposition of the magnetic film on the nonmagnetic base 420 tends to be nonuniform. The nonmagnetic base-supporting plate 421D shown in Figure 9 is advantageous for forming a magnetic film which has a sensitive crystal structure, such as a Co-Cr alloy film.

Referring to Figure 10, individual permanent magnets 445a and 445b are arranged in the target holder 412. Therefore, each target is provided with one magnetic field-generating means.

It is preferred in the above opposed targets sputtering device that the magnetic field-generating means comprise: a first means for generating a magnetic field around a pair of targets, said first means having such a configuration as to surround the pair of targets; and a second means for producing a magnetic flux, said second means being connected to said first means via a magnetic path formed between the first and second means.

Referring to Figure 11, the opposed-targets sputtering device is provided with a pair of targets T_1 and T_2, target holders 311 and 312, and conduits 311a and 312a. The vacuum vessel is denoted by 310. The first means comprise cores 301 and 302, which are electrically connected to the vacuum vessel 310. The cores 301 and 302 have the same configuration as the shields 17, 18 in Figure 1 and may be a cylindrical. The insulating spacers 315 and 316 are inserted between the cores 301 and 302 and the target holders 311 and 312, so that a distance of a few millimeters is created. The cores 301 and 302 are provided at the top ends thereof with front portions 301a and 302a, which are opposed and between which a magnetic field is generated. The cores 301 and 302 and their front portions 301a and 302a may be made of mild steel, silicon steel, Permalloy, or other soft magnetic materials having a high permeability and a high saturation magnetisation. The second means may be a magnetizing coil or a permanent magnet. In Figure 11, the second means are two magnetizing coils 301′ and 302′ which are located outside the vacuum vessel 310. When the magnetizing coils 301′ and 302′ mounted on the cores 301 and 302 are energized, the cores 301 and 302 produce a magnetic field H. The intensity of the magnetic field H can be easily adjusted by controlling the current of the magnetizing coils 301′ and 302′.

It is preferred in the above opposed-targets sputtering device, that one end of a magnetic-field generating means said end being closest to the targets, consist of soft magnetic material having a high permeability. Referring to Figure 10, for example the permanent magnet 445a comprises a magnet body 445a′ and a tip 446a which consists of soft magnetic material having a high permeability and a high saturation magnetisation. Since the demagnetizing field induced in the permanent magnet 445a, can be decreased by the tip 446a, the magnetic flux is concentrated around the outer periphery of the target T_{B1}. Targets T_{A1} and T_B can be uniformly eroded, but this is not the case when the cylindrical permanent magnet 445b is used. It is preferred that the tip have a pointed configuration at its outside front end.

Referring to Figures 14 and 15, it is illustrated how the erosion of targets made of Co-20 wt-% Cr alloy is varied by changing the construction of the magnetic field generating means. Symbols used in these figures indicate the following.

TG_1: The permanent magnets were as shown in Figure 1 and the sputtering power was 1045 W.

TG_2: The permanent magnets were as shown in Figure 10 were used and the sputtering power was 1027 W.

TG_3: The magnetic field generating means as shown in Figure 11 was used and the sputtering power was 1079 W.

It will be apparent that in TG_3 erosion of the target is the most uniform. Distribution of erosion and magnetic flux over the target in TG_2 are very uniform as compared with those of TG_1.

The method for producing the two-layer film according to the present invention may be carried out by using not only the opposed-targets sputtering devices shown in Figures 1, 7, 8 and 11 but also by using the opposed-targets sputtering devices shown in Figures 12 and 13. In Figure 12, the same members as those in Figure 1 are denoted by the same reference numerals. The magnetic-field generating means in Figure 12 is a magnetizing coil 430 disposed outside the vacuum vessel 10. The opposed targets sputtering device shown in Figure 13 is provided with the first and second means described with reference to Figure 11 and the nonmagnetic-base conveying means described with reference to Figures 7 and 8, as will be apparent from the reference numerals given in these drawings. It should be understood that the opposed-targets sputtering devices shown in Figures 1, 7, 8, 11, 12 and 13 are not limitative at all for carrying out the method of the present invention.

In carrying out the method of the present invention, it is preferred that the Co-Cr alloy layer be formed on the Co-Ta alloy layer no later than ten hours after formation of the Co-Ta alloy layer. The Co-Cr alloy layer is highly likely to peel off of the Co-Ta alloy layer if the nonmagnetic base having Co-Ta alloy layer thereon is cooled in vacuum to room temperature, is taken out of the opposed target sputterinig device, is exposed to ambient air for a long period of time, and is subsequently subjected to the formation of Co-Cr alloy layer. The surface, of these alloy layers are very smooth. If the exposure time of the Co-Ta alloy layer to th ambi nt air is less than ten hours, the adh sion of the Co-Ta alloy layer and the Co-Cr alloy layer is acceptable practically. If the Co-Ta alloy layer is not at all exposed to the ambient air and the Co-Cr alloy

Th present invention is now explained by way of examples.

Example 1

Samples of the perpendicular magnetic recording medium were prepared under the following conditions:

A. The opposed-Targets Sputtering Device (Figure 1)

(1) Material of the Targets T_1, T_2:
Target T_1 (100 atomic % Co)
Target T_2
(100 atomic % Co—I (Co)—and 100 atomic% Ta—II (Co)—.

(2) Distance Between the Targets T_1, T_2:
75 mm

(3) Magnetic Field in the Neighborhood of the Targets T_1, T_2:
(100~200 gauss) $100 \cdot 10^{-4}$~$200 \cdot 10^{-4}$T

(4) Dimension of the Targets T_1, T_2:
110 mm in diameter (Round Disc Targets)

(5) Distance of the Nonmagnetic Base 40 From the Ends of the Targets T_1, T_2:
30 mm

B. Nonmagnetic Base 40:

A 25 µm thick polyimide film (produced by Dupont and sold under the trademark CAPTON) and a 16 µm thick polyethylene terephthalate (PET) film (both of these films were used in the experiments).

The two-layer films were produced by the following procedure.

The nonmagnetic base 40 was first fixed on the base holder 41 and then the gas in the vacuum vessel 10 was exhausted until an ultimate degree of vacuum of $133 \cdot 10^{-6}$ Pa (1×10^{-6} Torr) or less was achieved. Subsequently, an argon gas was admitted into the vacuum vessel 10 until the pressure was increased to 4 mm Torr. After pre-sputtering for three to five minutes, the shutter (not shown in Figure 1) was retracted and the formation of a Co-Ta alloy layer on the nonmagnetic base 40 was initiated. The electric power during sputtering was 250 W or 500 W and a 0.55 µm thick Co-Ta alloy layer was formed. This procedure was repeated while varying the Ta concentration of the Co-Ta alloy layers. The coercive force in plane H_c and the saturation magnetization M_s of the produced Co-Ta alloy layers were measured. The results are shown in Figure 3.

As will be apparent from Figure 3, the coercive force in plane H_c was 8 kA/m (100 Oe) or more and the saturation magnetization was $110 \cdot 4\pi \cdot 10^{-4}$T (110 Oemu/cc) or more when the Ta concentration of the Co-Ta alloy was 15% by weight (5.4 atomic percent) or less. The coercive force in plane H_c and the saturation magnetization M_s decreased with an increase in the Ta concentration. The Co-Ta alloy had an excellent soft magnetic property, i.e., a coercive force in plane H_c of 0.4 kA/m (5 Oe) or less, when the Ta concentration was 23% by weight (8.9 atomic percent) or more.

The Co-Ta alloy layers were subjected to X-ray diffraction analysis. When the Ta concentration was 22% by weight (8.4 atomic percent) or less, the diffraction peak was at an angle (2θ) of from 43.80 to 44.02. When the Ta concentration was 23% by weight or more, a diffraction peak was not detected, thus revealing the Co-Ta alloy layer to be amorphous.

Measurement of the resistivity also revealed the Co-Ta alloy layer containing 23% by weight or more of Ta to be amorphous.

The properties of several samples are given in Table 1 below.

TABLE 1

Sample No.	Base	Ta concentration wt%	Diffraction peak	H_c kA/m	H_c Oe
I—1	Capton	9.2	Detected	9.7	121
I—2	PET	22.5	Detected	0.74	9.3
I—3	Capton	23.5	None	0.16	2.0
I—4	PET	24.0	None	<0.04	<0.5

Example 2

The nonmagnetic bases on which a Co-Ta alloy layer was formed according to th procedure of Example 1 were cooled in a vacuum down to room temperature and then were removed from the opposed-

base holder 41 (Figure 4) and the Co-Cr alloy layer was formed on the Co-Ta alloy layer. The Co-Cr alloy layer was formed under the following conditions:

A. The Opposed-Targets Sputtering Device (Figure 1)

(1) Material of the Targets T_1, T_2:
Co-Cr alloy containing 17% by weight of Cr

(2) Distance Between the Targets T_1, T_2:
100 mm

(3) Magnetic Field in the Neighborhood of the Targets T_1, T_2:
(100~200 gauss) $100 \cdot 10^{-4}$ T~$200 \cdot 10^{-4}$ T

(4) Dimension of the Targets T_1, T_2:
150 mm×100 mm×10 mm (thickness)

(5) Distance of the Nonmagnetic Base 40 From the Ends of the Targets T_1, T_2:
50 mm

(6) Target holder (Figure 4)—three nonmagnetic bases 40 were mounted on holders 42 which were secured on a holding body 44 which was rotated around a rotatable driving shaft 43. The rotatable driving shaft 43 were rotated at an almost constant speed.

B. Nonmagnetic Base 40

A 25 µm thick Capton film and a 16 µm thick polyethylene terephthalate (DET) film. The Co-Ta alloy layer was formed on these films by the same procedure as that used in of Example 1 except that the target holder 40 was rotated at 40 rpm and the sputtering power was 1000 W. For the purpose of comparison, one-layer films were produced by the procedure described above.

The half-value width $\Delta\theta_{50}$ of the Co-Cr alloy layer of the two-layer films and the one-layer films was measured. The results are shown in Figure 5. As is apparent from Figure 5, the half-value width $\Delta\theta_{50}$ of two-layer films is very excellent when the Ta concentrations (3 degree) is 23% by weight or more. A Ta concentration of 23% by weight corresponds to the structural change of the Co-Ta alloy, i.e., the crystal structure is changed to an amorphous structure and vice versa. Surprisingly, the half-value width $\Delta\theta_{50}$ of the two-layer films was very low, e.g. 5 degree and could be decreased more than that of the single-layer films, when the Co-Ca alloy layer of the two-layer films had an amorphous structure.

The properties of several samples are given in Table 2.

TABLE 2

Sample No.	Nonmagnetic base	Ta concentration (wt%)	Co-Ta alloy layer: Diffraction peak	Co-Ta alloy layer: Remarks	Co-Cr alloy layer: Diffraction peak	Co-Cr alloy layer: Diffraction peak $\Delta\theta_{50}$
II—1	Capton	—	—	Single	44.51°	3.5°
II—2	〃	9.2	43.94	No. I—1	None	—
II—3	〃	15.8	43.85	—	44.53	8.7
II—4	〃	23.5	None	No. I—3	44.55	3.0
II—5	〃	23.6	None	—	44.54	2.6
II—6	PET	—	—	Single	44.57	4.2
II—7	〃	22.5	None	No. I—2	44.60	3.7
II—8	〃	38.8	None	—	44.58	3.6

Remarks

(1) The diffraction Peak of a (002) plane was measured and is given by angle (2θ).

(2) "Single" indicates a single-layer film.

As is apparent from Table 2, the Co-Ta alloy is crystalline when the Ta concentration is 22% by weight (8.4 atomic %) or less. The crystal structure of th Co-Ta alloy is an hcp structure and the Co-Ta crystals are oriented along the C-axis of the hcp structure. The distance between the C planes of the Co-Ta crystals is

The surface and cross section patterns of two-layer films was investigated by means of a diffraction electron microscope produced by Japan Electron Co., Ltd. (JSM-35C type).

The specimens for observing the surface pattern were prepared by depositing an Au-Pd layer on the perpendicular magnetic recording layers to a thickness of approximately 20 nm (200 Å). Electron microscopic photographs were taken at a magnification of 40,000 and under an acceleration voltage of 25 kV. The specimens for observing the cross section pattern were prepared by putting the two layer films into a gelation capsule together with ethyl alcohol, cooling the capsule with liquid nitrogen for two hours, and then cleaving the capsule with a cleaving knife. The device used for the freeze-cleaving method was a TF-1-type device produced by Eiko Engineering Co., Ltd.

The surface pattern of the Co-Cr alloy layer was composed of uniform particles of 50 nm (500 Å) or less in size and the cross section patterns of the Co-Cr alloy layer and the Co-Ta alloy layer exhibited virtually no grain boundaries and were composed of a few fragmented particles which were dispersed. A very flat boundary was observed between the Co-Cr alloy layer and the Co-Ta alloy layer. The adhesion of these layers to each other was tested by changing the time between the completion of formation of the Co-Ta alloy layer and the initiation of formation of the Co-Cr alloy layer. When the Co-Ta alloy layer was exposed to the ambient air for a few days, the above-mentioned adhesion was very poor and the Co-Cr alloy layer was very susceptible to peeling. A satisfactorily high adhesion could be obtained by keeping the exposure time shorter than ten hours.

Example 3

The procedure of Example 2 was repeated except for the following:

A. Distance of the Nonmagnetic Base 40
From the Ends of the Targets:
25 mm

B. Target Holders:
The holders 42 were provided with a cooling means (not shown in Figure 4) located behind them.

C. The nonmagnetic bases 40 were kept stationary during sputtering.

The electric power amounted to 5 kW at the highest during sputtering and the thickness of the Co-Cr-alloy layer was approximately 0.5 µm. The deposition rate was varied in the range of from approximately 0.1 µm/min to approximately 0.7 µm/min.

The relationship between the half-value width $\Delta\theta_{50}$ and the deposition rate (Rd) is shown in Figure 6. In Figure 6, the symbols ○ and ● indicate one-layer films and two-layer films, respectively, in which a PET film was used as the nonmagnetic base 40. As is apparent from Figure 6, it is possible to produce two-layer films having an excellent half-value width $\Delta\theta_{50}$ at a high deposition rate of up to approximately 0.7 µm/min by using a PET film as the nonmagnetic base.

In the present example, the influence of cooling upon the properties of two-layer films was tested. In the test, the holders 42 (Figure 4) were made of a stainless steel sheet having a surface roughness of from 0.1S to 0.6S and the nonmagnetic bases 40 were cooled via the holders 42, behind which a cooling chamber (not shown) was defined. The temperature of the holders 42 was varied in the range of from 25°C to 80°C, and the vertical coercive force H_{cv} of the Co-Cr alloy layer was varied from 16 to 32 kA/m (200 to 400 Oe).

When the holders 42 made of a mat or satin-finished stainless steel sheet was used in the test mentioned above the temperature of the holders was 25°C, vertical coercive force H_{cv} was 66.4 kA/m (830 Oe). In this case, the deposition rate was 0.3 µm/min.

In the case of both the holders made of a 0.1S—0.6S stainless steel sheet and the holders made of a satin-finished stainless steel sheet, the half-value width $\Delta\theta_{50}$ was approximately 3 degrees.

Example 4

A conventional two-layer film and a two-layer film according to the present invention were prepared according to the procedure of Example 2.

The layer of low coercive-force material of the conventional two-layer film consisted of an alloy comprised of 4% Mo, 78% by weight of Ni, and 18% by weight of Fe. The Co-Ta alloy layer of the two-layer film according to the present invention contained 30% by weight of Ta. The properties of these films are given in Table 3.

TABLE 3

Sample No.	Layer of low coercive-force material: Thickness (μm)	Layer of low coercive-force material: Coercive force in plane kA/m	Layer of low coercive-force material: Coercive force in plane Oe	Co-Cr alloy layer: Thickness (μm)	Co-Cr alloy layer: Vertical coercive force (H_{cv}) kA/m	Co-Cr alloy layer: Vertical coercive force (H_{cv}) Oe	Co-Cr alloy layer: Halfvalue width $\Delta\theta_{50}$ (degree)
IV—1	0.5	0.08	1.0	0.5	18.4	230	3.0
IV—2	0.4	0.08	1.0	0.5	28.8	360	10

The recording characteristic of the above-mentioned two films was measured by using the perpendicular magnetic head described in IEEE Trans. on Mag., Vol. MAG-16, No. 1, Jan. 1980, page 71.

The regenerating peak-to-peak voltage was measured while the kilo flux reversal per 2.54 cm (inch) (KFRPI) was varied from 1.0 to 100. The results are given in Table 4.

TABLE 4

Sample No.	Recording condition (KFRPI) 1.0 mV	2.0 mV	5.0 mV	10 mV	20 mV	50 mV	100 mV
IV—1 (Invention)	160	160	160	150	150	140	80
IV—2 (Prior art)	240	240	230	210	160	90	25

As is apparent from Table 4, when the recording condition in terms of KFRPI was from 1 to 5, the regenerating peak-to-peak voltage of Sample No. IV—1 was higher than that of Sample No. IV—2. This was due to the fact that the vertical coercive force H_{cv} of Sample No. IV—2 was higher than that of Sample No. IV—1. However, the peak-to-peak regenerating voltage of Sample No. IV—2 drastically decreased when the KFRPI was 50 or more. Sample No. IV—1 did not exhibit such a drastic decrease at all, and it is believed that the reason for this was an excellent half-value width $\Delta\theta_{50}$.

Example 5

The nonmagnetic bases on which a Co-Ta alloy layer was formed according to the procedure of Example 1 (Sample No. I—4) were cooled in a vacuum down to room temperature and then were removed from the opposed-targets sputtering device.

The procedure of Example 1 was repeated for forming a Co-Cr alloy layer except that the following was changed.

(1) Target T_1:
A Ta plate consisting of 100% of Ta was positioned on a portion of the Co-Cr alloy plate containing 17 atomic % of Cr

(2) Target T_2:
A plate consisting of Co-Cr alloy containing 17 atomic % of Cr

(3) Distance between Targets T_1, T_2:
120 mm

(4) Dimension of Targets T_1, T_2:
150 mm×100 mm×10 mm (Thickness)

(5) Distance of Nonmagnetic Base 40 From the Ends of Targets T_1, T_2:

(6) Distance of the Nonmagnetic Base 40 From the Ends of the Targets T_1, T_2:
50 mm

During sputtering the electric power was 1000 W and the argon gas pressure in the vacuum vessel was $532 \cdot 10^{-3}$ Pa (4×10^{-3} Torr). As a result of sputtering, a 0.5 µm thick Co-Cr alloy layer which contain Ta was formed. The Ta concentration of Co-Cr alloy layer was varied by changing the size of the Ta plate. For the purpose of comparison, a one layer-film was produced and 16 µm thick PET film by the procedure described above.

The two-layer films and the one-layer film produced were subjected to measurement of the perpendicular coercive force Hcv, the coercive force in plane Hc, the perpendicular residual magnetization, Mrv, the residual magnetization in plane Mrh, and the anisotropic magnetic field Hk. The results are shown in Table 5.

TABLE 5

Sample No.	Nonmagnetic base	Properties of Co-Cr layer: Composition (atomic %) Co	Cr	Ta	$\Delta\theta_{50}$	Hcv/Mrv Hch	Mrh	Hcv Oe	Hcv kA/m	Hk kOe	Hk kA/m	Remarks
V—1	PET	80.9	16.3	2.8	4.8	0.61	0.18	62	4.96	1.6	128	
V—2	"	79.9	16.3	3.8	3.6	3.08	1.18	222	17.8	2.5	200	
V—3	"	79.4	16.5	4.1	4.3	7.41	2.54	335	26.8	2.2	176	Two layer films
V—4	"	77.6	16.6	5.8	4.4	5.96	2.65	402	32.2	—	—	
V—5	"	77.9	16.0	6.1	5.6	2.06	0.92	175	14	1.7	136	
V—6	"	77.3	15.6	7.1	4.5	1.45	0.81	123	9.84	2.2	176	
V—7	"	77.0	15.5	8.5	4.7	1.50	0.82	65	5.2	1.2	96	
V—8	"	83	17	0	3.5	0.81	0.25	145	11.6	2.4	192	One-layer film

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As is apparent from Table 5, the half value width $\Delta\theta_{50}$ of the Co-Cr alloy layer containing Ta is slightly inferior to but is virtually the same as that of the Co-Cr alloy layer of the one-layer film. The half value width $\Delta\theta_{50}$ of the Co-Cr alloy layer containing Ta is not deteriorated greatly due to the layer of low coercive force material.

As is apparent from Hcv/Hc and Mrv/Mrh given in Table 5, the perpendicular orientation of the two-layer films is considerably improved over that of the one-layer film, when the Ta concentration of Co-Cr alloy is from 3.8 atomic % to 7.1 atomic %. This makes it possible to enhance the recording density and recording sensitivity as compared with those of a known one-layer film.

Claims

1. A perpendicular magnetic recording medium comprising a nonmagnetic base and two magnetic layers formed successively on said nonmagnetic base, said two magnetic layers consisting of a first layer of a low-coercive force material and a second layer of a cobalt alloy which has a direction of easy magnetization perpendicular to the surface of the recording medium, characterized in that said first layer of low-coercive material consists of an alloy which is mainly composed of cobalt and additionally of tantalum, and said second cobalt alloy layer has a composition different from said first layer of a low-coercive material.

2. The perpendicular magnetic recording medium according to claim 1, characterized in that the Ta concentration of said Co-Ta alloy of said first magnetic layer is from 5.4 atomic % to 24.6 atomic %.

3. The perpendicular magnetic recording medium according to claim 2, characterized in that said Co-Ta alloy of said first layer is amorphous.

4. The perpendicular magnetic recording medium according to claim 1, characterized in that said cobalt alloy of said second layer additionally contains Cr.

5. The perpendicular magnetic recording medium according to claim 1, characterized in that said cobalt alloy of said second layer additionally contains Cr and Ta.

6. The perpendicular magnetic recording medium according to claim 5, characterized in that the Ta concentration of said cobalt alloy of said second layer is from 2 atomic % to 10 atomic %, with the proviso that sum of the Cr and Ta concentrations is 27 atomic % at the highest.

7. The perpendicular magnetic recording medium according to claim 1, characterized in that said nonmagnetic base is a polyethylene terephtalate film.

8. A method of producing the perpendicular magnetic recording medium according to one of claims 1 to 7, which method comprises forming successively two magnetic layers on a nonmagnetic base with said two magnetic layers consisting of a first layer of a low-coercive force material and a second layer of a cobalt alloy which has a direction of easy magnetization perpendicular to the surface of the recording medium, said method being characterized by the following steps:

producing said first layer of low-coercive force material by forming a layer consisting of an alloy which is mainly composed of cobalt and additionally of tantalum by an opposing target sputtering method wherein a magnetic field is generated in a direction perpendicular to the surfaces of a pair of targets (T_1, T_2) arranged opposite to one another within a sputtering device, and

producing said second layer consisting of a cobalt alloy having a composition different from said first layer of low-coercive material on said first layer formed on the nonmagnetic base by the opposing target sputtering method, herein the base (40) is located beside a space between said pair of targets (T_1, T_2) and faces said space so as to deposit a cobalt alloy layer having a direction of easy magnetisation perpendicular to the base.

9. The method according to claim 8, characterized in that said second layer is formed no later than 10 hours after forming said first layer.

10. The method according to claim 9, characterized in that said second layer and said first layer of Co-Ta alloy are formed consecutively.

Patentansprüche

1. Medium für senkrechte magnetische Aufzeichnung, umfassend:

eine nicht-magnetische Basis und zwei magnetische Schichten, die nacheinander auf der nicht-magnetischen Basis ausgebildet sind, wobei die beiden magnetischen Schichten aus einer ersten Schicht aus einem Material mit niedriger Koerzitivkraft und einer zweiten Schicht aus einer Kobaltlegierung bestehen, bei der die Richtung der einfachen Magnetisierung senkrecht zur Oberfläche des Aufzeichnungsmediums verläuft,

dadurch gekennzeichnet, daß die erste Schicht aus einem Material mit niedriger Koerzitivkraft aus einer Legierung besteht, welche hauptsächlich aus Kobalt und zusätzlich aus Tantal zusammengesetzt ist, und daß die zweite Kobaltlegierungsschicht eine Zusammensetzung besitzt, die von der ersten Schicht aus einem Material mit niedriger Koerzitivkraft verschieden ist.

2. Medium für senkrechte magnetische Aufzeichnung nach Anspruch 1, dadurch gek nnzeichn t, daß die Ta-Konzentration der Co/Ta-Legierung der ersten magnetischen Schicht 5,4 Atom-% bis 24,6 Atom-%

3. Medium für senkrecht magnetische Aufzeichnung nach Anspruch 2, dadurch gekennzeichnet, daß die Co/Ta-Legierung der ersten Schicht amorph ist.

4. Medium für senkrechte magnetische Aufzeichnung nach Anspruch 1, dadurch gekennzeichnet, daß die Kobaltlegierung der zweiten Schicht zusätzlich Cr enthält.

5. Medium für senkrechte magnetische Aufzeichnung nach Anspruch 1, dadurch gekennzeichnet, daß die Kobaltlegierung der zweiten Schicht zusätzlich Cr und Ta enthält.

6. Medium für senkrechte magnetische Aufzeichnung nach Anspruch 5, dadurch gekennzeichnet, daß die Ta-Konzentration der Kobaltlegierung in der zweiten Schicht 2 Atom-% bis 10 Atom-% beträgt, mit der Maßgabe, daß die Summe der Cr- und Ta-Konzentrationen im Höchstfall 27 Atom-% beträgt.

7. Medium für senkrechte magnetische Aufzeichnung nach Anspruch 1, dadurch gekennzeichnet, daß die nichtmagnetische Basis eine Polyethylenterephtalatfolie ist.

8. Verfahren zum Herstellen des Mediums für senkrechte magnetische Aufzeichnung nach einem der Ansprüche 1 bis 7, welches (Verfahren) umfaßt:

nacheinander werden zwei magnetische Schichten auf einer nicht-magnetischen Basis ausgebildet, wobei die beiden magnetischen Schichten aus einer ersten Schicht aus einem Material mit niedriger Koerzitivkraft und einer zweiten Schicht aus einer Kobaltlegierung bestehen, welche eine Richtung der leichten Magnetisierung besitzt, die senkrecht zur Oberfläche des Aufzeichnungsmediums verläuft,

wobei das Verfahren durch folgende Schritte gekennzeichnet ist:

die erste Schicht aus Material mit niedriger Koerzitivkraft wird hergestellt, indem eine Schicht gebildet wird, die aus einer Legierung besteht, die hauptsächlich aus Kobalt und zusätzlich aus Tantal zusammengesetzt ist (und zwar) durch ein Sprüh-(Verdampfungs-)Verfahren mit gegenüberliegenden Targets, bei dem ein magnetisches Feld in einer Richtung senkrecht zu den Oberflächen eines Paares von Targets (T_1, T_2) erzeugt wird, die einander gegenüberliegend in einer Sprüh-(Verdampfungs-)Vorrichtung angeordnet sind, und

auf der ersten Schicht, die auf der nicht-magnetischen Basis durch das Sprüh-(Verdampfungs-)Verfahren mit gegenüberliegenden Targets hergestellt wurde, wird die zweite Schicht erzeugt, welche aus einer Kobaltlegierung besteht, die eine von der ersten Schicht aus einem Material mit niedriger Koerzitivkraft verschiedene Zusammensetzung aufweist, wobei die Basis (40) neben einem Raum zwischen dem Paar von Targets (T_1, T_2) angeordnet ist und dem Raum so zugewandt ist, daß eine Kobaltlegierungsschicht abgeschieden wird, die eine zu der Basis senkrechte Richtung leichter Magnetisierung aufweist.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß die zweite Schicht nicht später als 10 Stunden nach der Ausbildung der ersten Schicht hergestellt wird.

10. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß die zweite Schicht und die erste Schicht aus einer Co/Ta-Legierung nacheinander hergestellt werden.

Revendications

1. Support d'enregistrement à magnétisation perpendiculaire, comportant une base non magnétique et deux couches magnétiques formées successivement sur ladite base non magnétique, les deux couches magnétiques étant constituées d'une première couche d'un matériau à force coercitive faible et d'une seconde couche d'un alliage de cobalt qui présente une direction de magnétisation facile perpendiculaire à la surface du support d'enregistrement, caractérisé en ce que la première couche de matériau à force coercitive faible est constituée d'un alliage principalement composé de cobalt et en outre de tantale et en ce que la second couche d'alliage de cobalt présente une composition différente de celle de la première couche de matériau à force coercitive faible.

2. Support d'enregistrement à magnétisation perpendiculaire selon la revendication 1, caractérisé en ce que la concentration en Ta de l'alliage Co-Ta de la première couche magnétique est comprise entre 5,4 atomes % et 24,6 atomes %.

3. Support d'enregistrement à magnétisation perpendiculaire selon la revendication 2, caractérisé en ce que l'alliage Co-Ta de la première couche est amorphe.

4. Support d'enregistrement à magnétisation perpendiculaire selon la revendication 1, caractérisé en ce que l'alliage de cobalt de la seconde couche contient en outre du Cr.

5. Support d'enregistrement à magnétisation perpendiculaire selon la revendication 1, caractérisé en ce que l'alliage de cobalt de la seconde couche contient en outre du Cr et du Ta.

6. Support d'enregistrement à magnétisation perpendiculaire selon la revendication 5, caractérisé en ce que la concentration en Ta de l'alliage de cobalt de la seconde couche est comprise entre 2 atomes % et 10 atomes % sous réserve que la somme des concentrations en Cr et en Ta soit au maximum de 27 atomes %.

7. Support d'enregistrement à magnétisation perpendiculaire selon la revendication 1, caractérisé en ce que la base non magnétique est un film de téréphtalate de polyéthylène.

8. Procédé de fabrication du support d'enregistrement à magnétisation perpendiculaire selon l'une d s revendications 1 à 7, ce procédé comportant la formation successive de deux couches magnétiques sur une base non magnétique, les deux couches magnétiques étant constituées d'une première couche d'un

de magn´tisation facile perpendiculaire à la surface du support d'enregistrement, le procédé étant caractérisé par les étapes suivantes:

fabriquer la première couche de matériau à force coercitive faible en formant une couche constituée d'un alliage qui est principalement composé de cobalt et additionnellement de tantale par un procédé de pulvérisation cathodique à cibles placées face à face, dans lequel un champ magnétique est créé dans une direction perpendiculaire aux surfaces d'une paire de cibles (T_1, T_2) disposées en face l'une de l'autre à l'intérieur d'un dispositif de pulvérisation cathodique, et

fabriquer la seconde couche, constituée d'un alliage de cobalt d'une composition différente de celle de la première couche de matériau à faible force coercitive, sur ladite première couche formée sur la base non magnétique, par le procédé de pulvérisation cathodique à cibles placées face à face dans lequel la base (40) est située à côté d'un espace existant entre ladite paire de cibles (T_1, T_2) et fait face audit espace de façon à déposer une couche d'alliage de cobalt présentant une direction de magnétisation facile perpendiculaire à la base.

9. Procédé selon la revendication 8, caractérisé en ce que l'on forme la seconde couche au plus tard 10 heures après la formation de ladite première couche.

10. Procédé selon la revendication 9, caractérisé en ce que l'on forme successivement la seconde couche et la première couche d'alliage Co-Ta.

Fig. 1

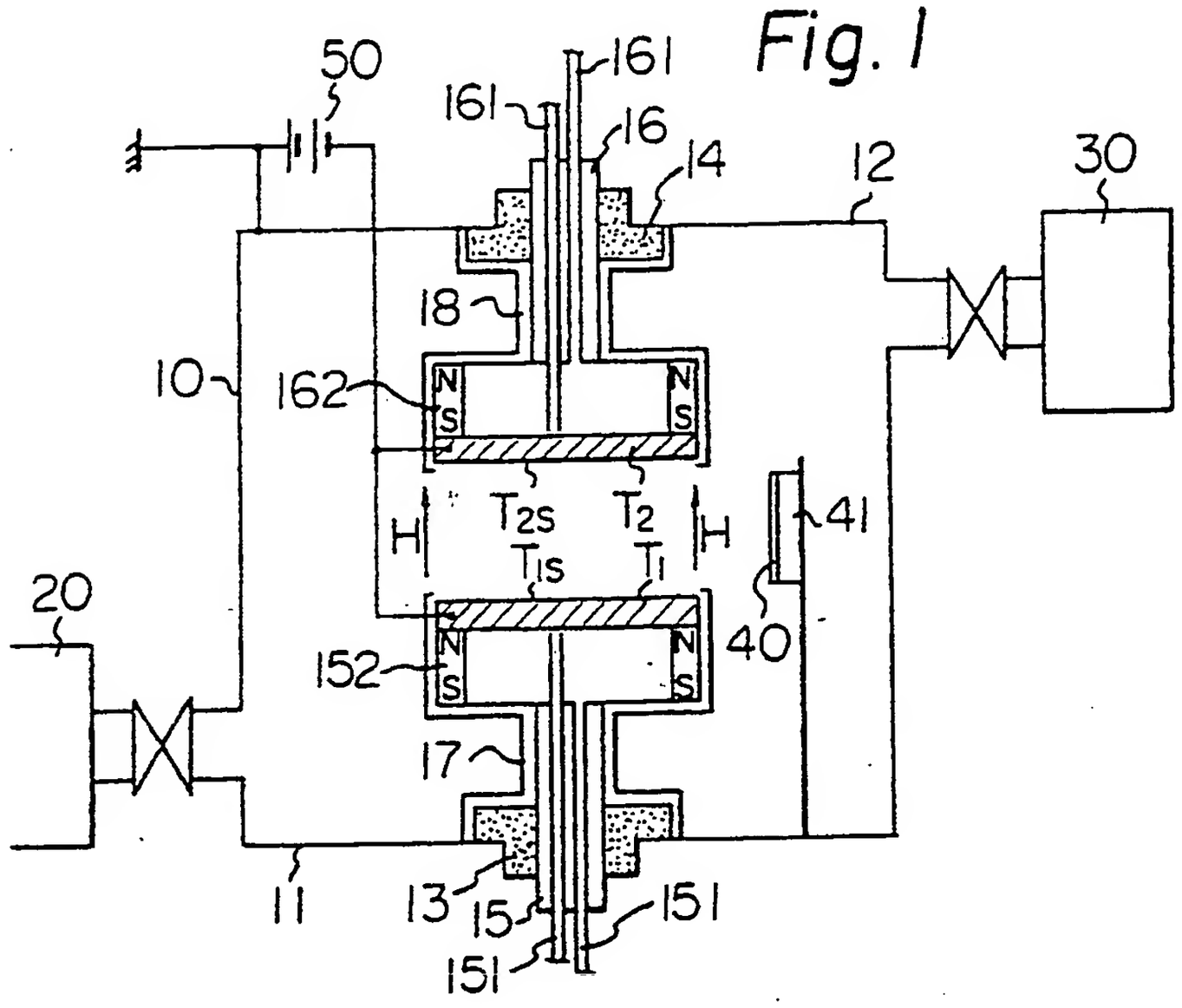

50
161
161
16
14
12
30
18
10
162
N
S
N
S
H
T2S
T2
H
T1S
T1
41
20
40
152
N
S
N
S
17
11
13
15
151
151

Fig. 2

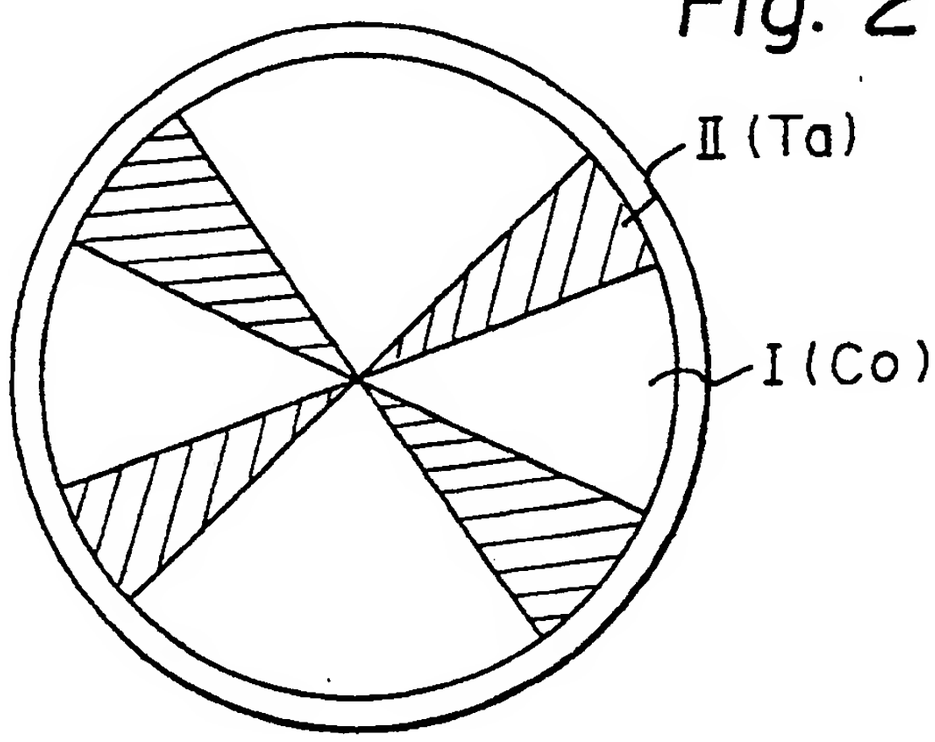

II (Ta)
I (Co)

Fig. 3

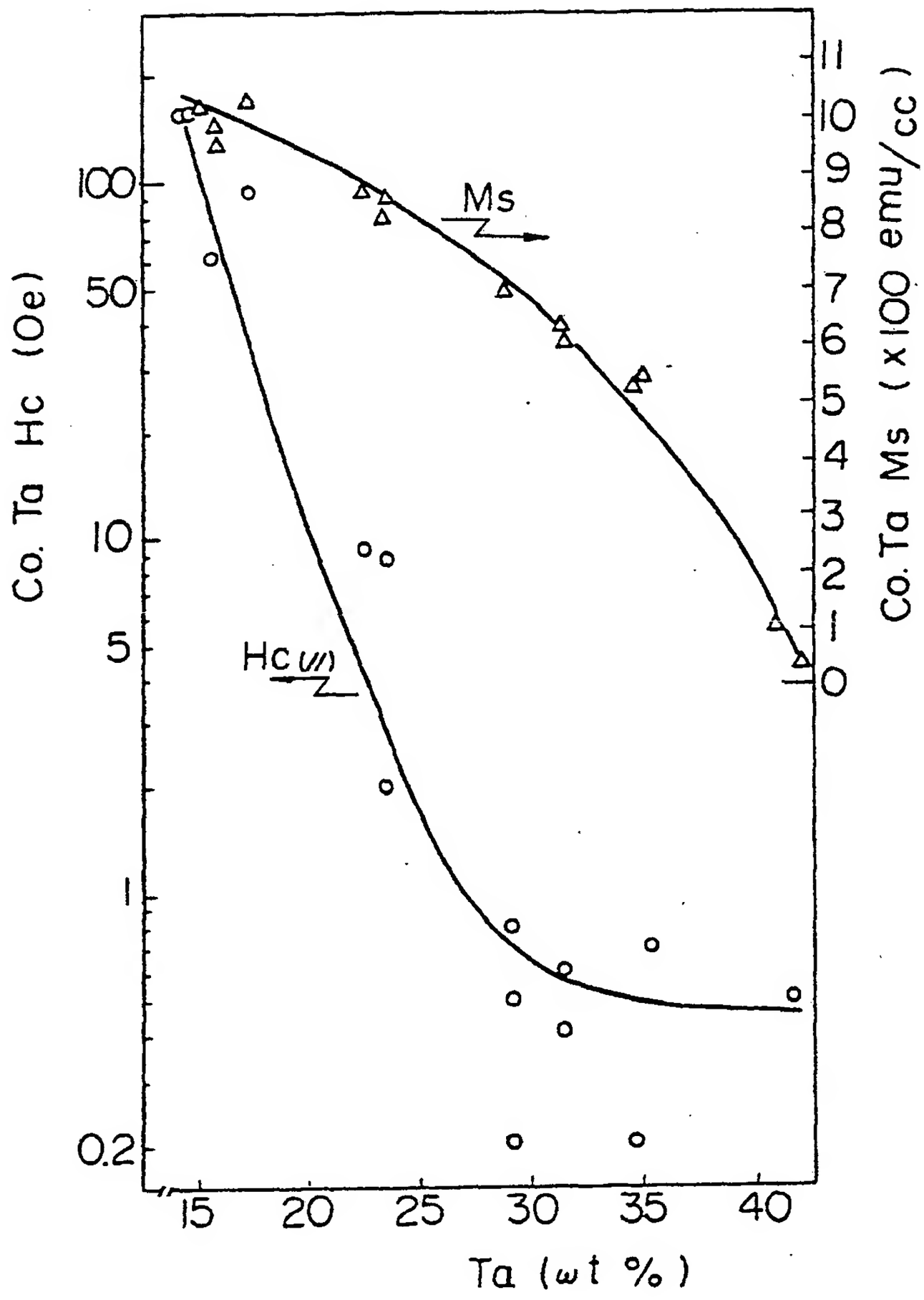

Co. Ta Hc (Oe)
100
50
10
5
1
0.2
Ms
Hc ⊥
Hc //
11
10
9
8
7
6
5
4
3
2
1
0
Co. Ta Ms (x100 emu/cc)
15
20
25
30
35
40
Ta (wt %)

Fig. 4

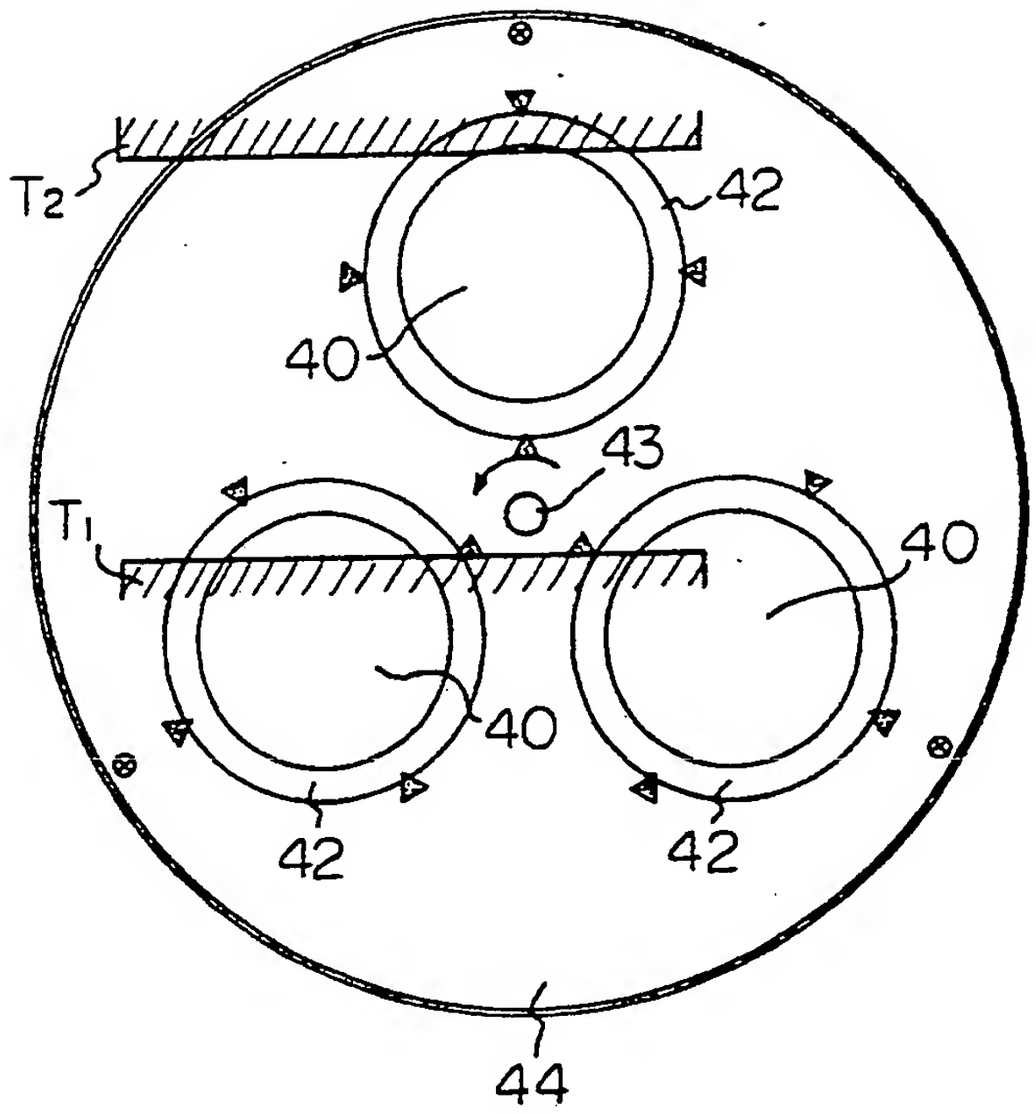


Fig. 5

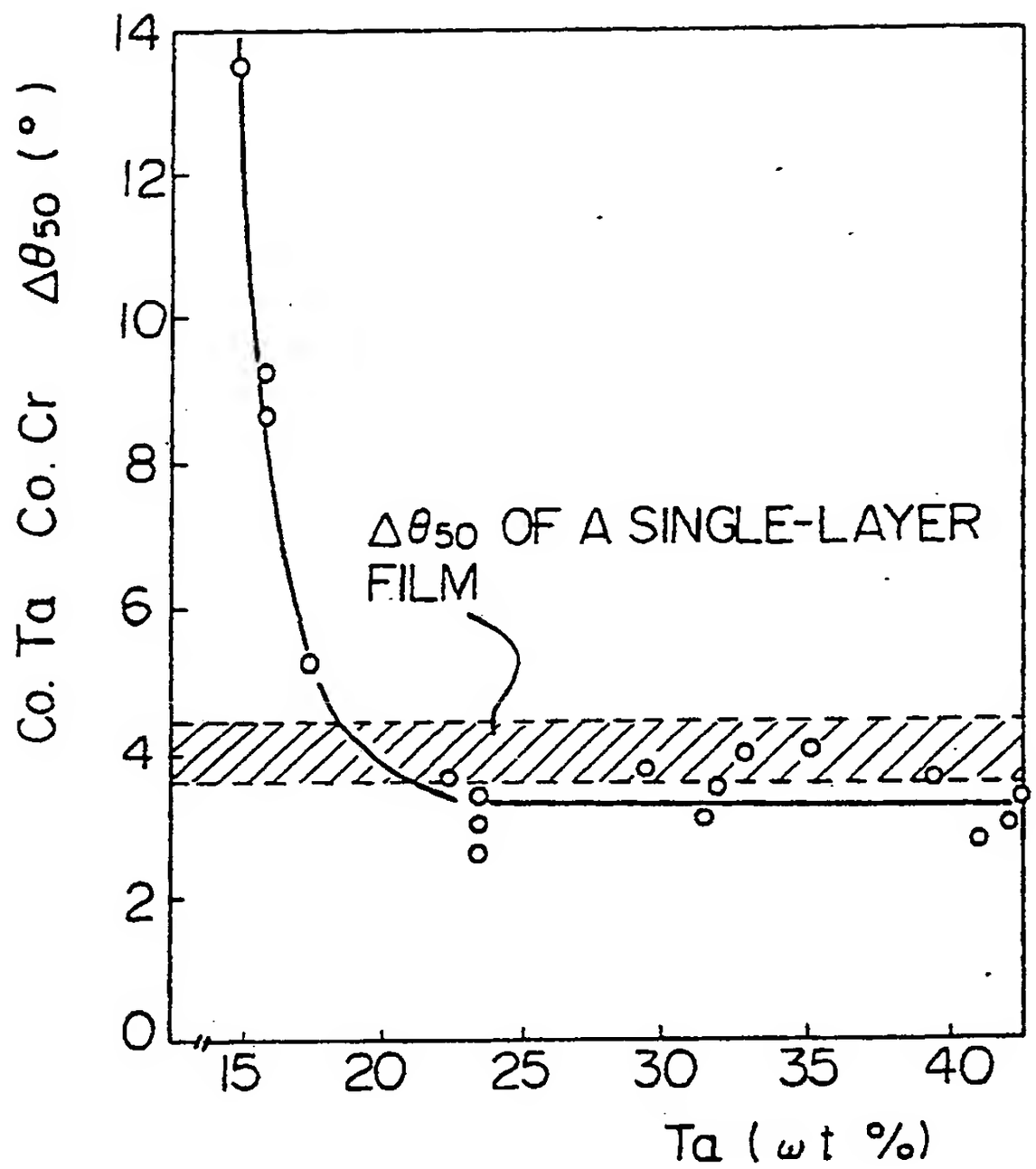

Co. Ta Co. Cr Δθ50 (°)
14
12
10
8
6
4
2
0
15
20
25
30
35
40
Ta (ωt %)
Δθ50 OF A SINGLE-LAYER FILM

Fig. 6

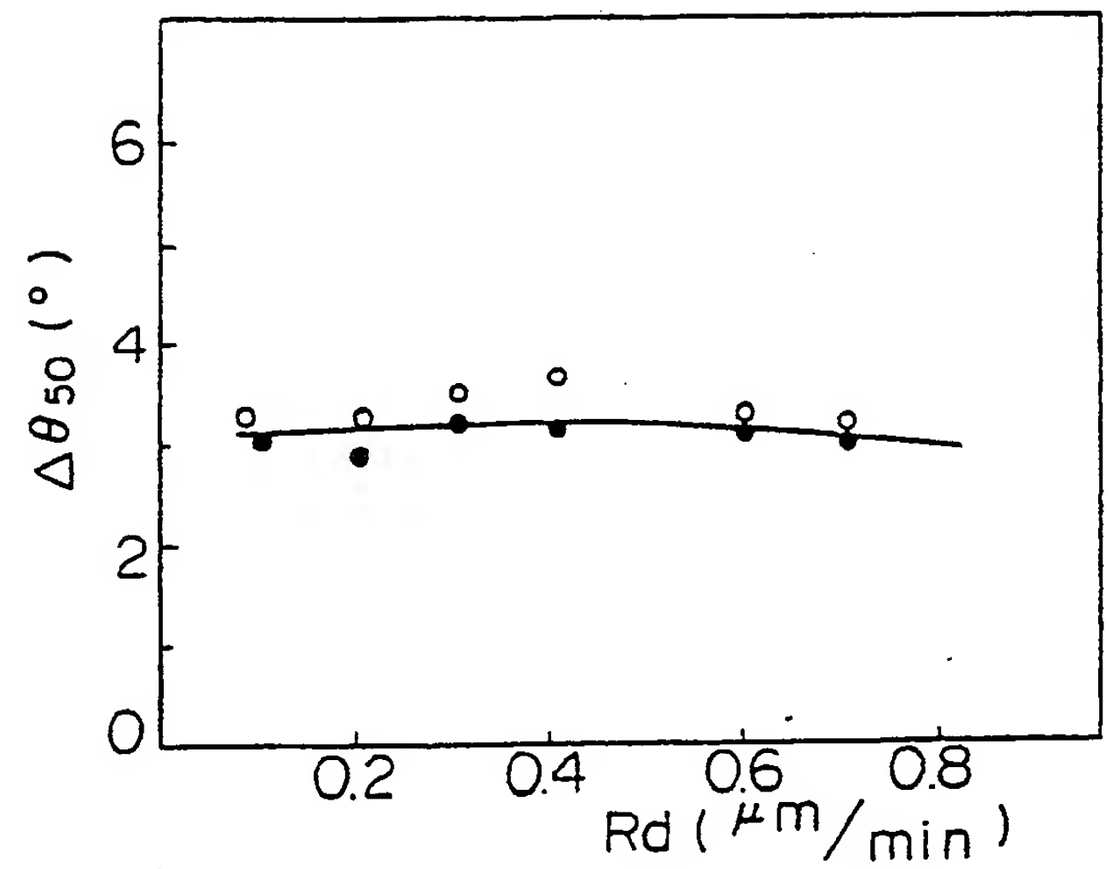
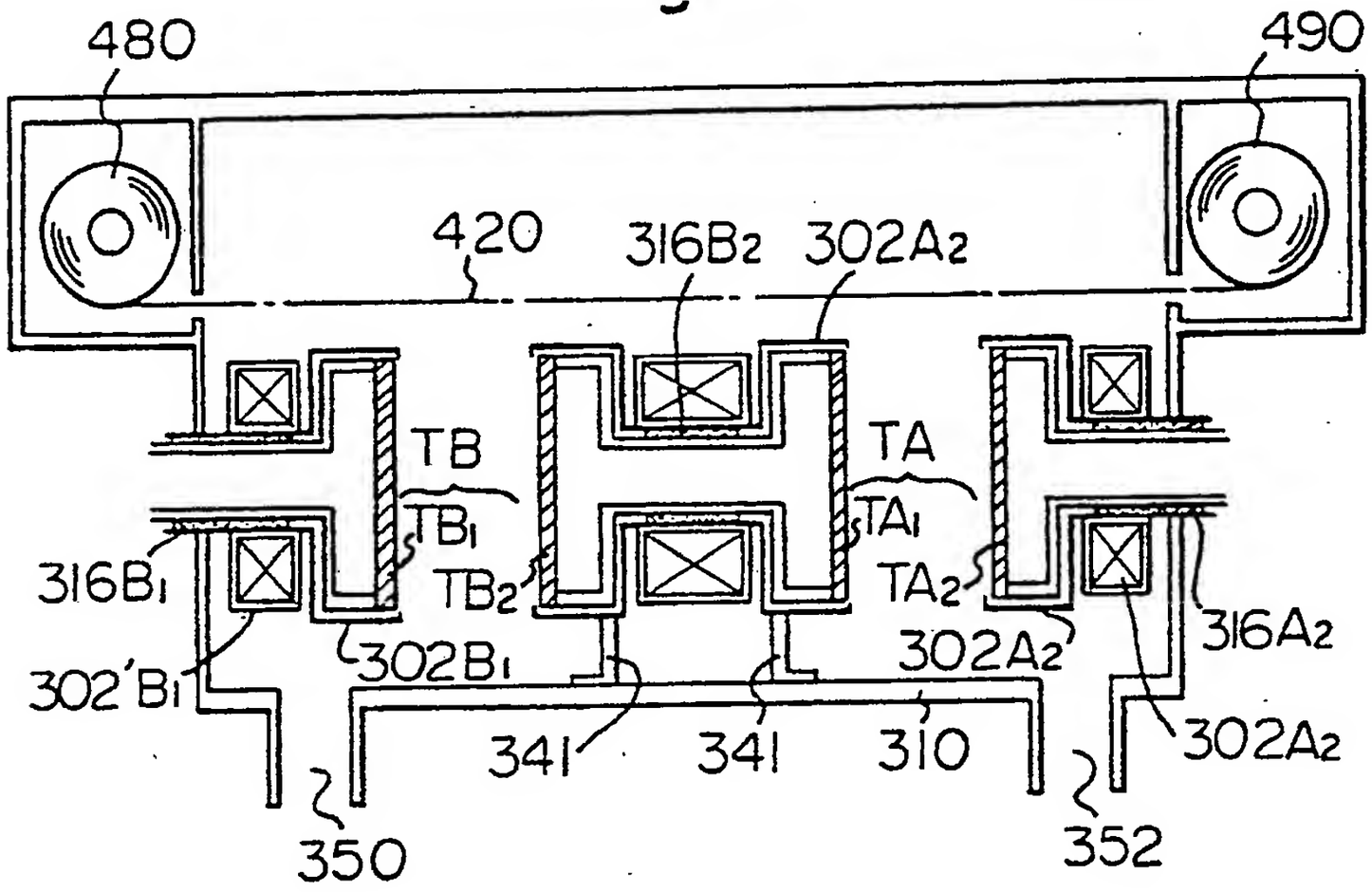

6
4
2
0
$\Delta\theta_{50}$ (°)
0.2
0.4
0.6
0.8
Rd (μm/min)

Fig. 13


480
490
420
316B2
302A2
TB
TA
TB1
TA1
316B1
TB2
TA2
302A2
316A2
302'B1
302B1
341
341
310
302A2
350
352

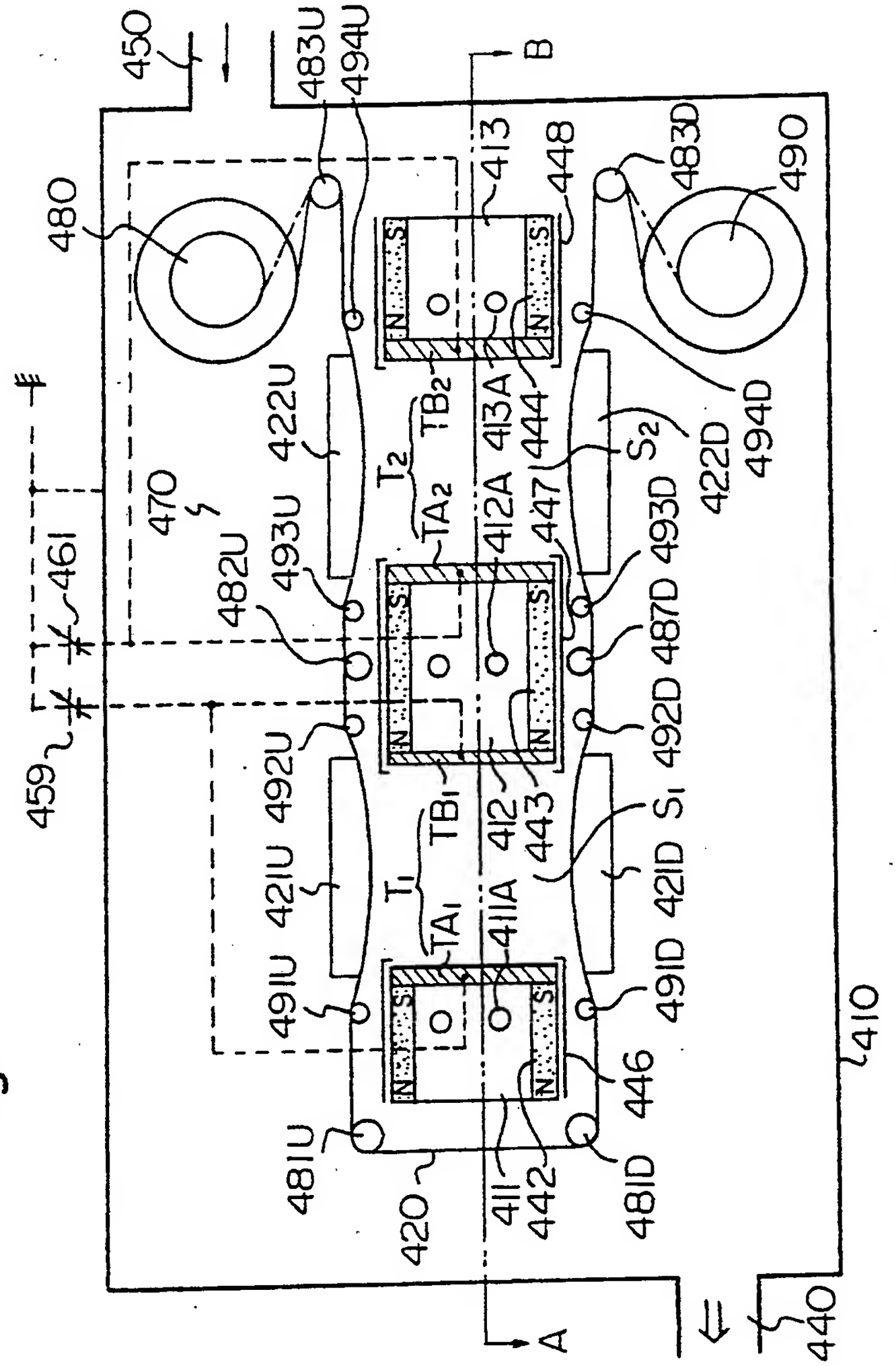

450
483U
494U
B
480
470
482U
493U
422U
459
461
492U
421U
491U
481U
420
T1
TB1
TA1
411A
412
443
411
442
T2
TB2
TA2
412A
413A
444
447
448
413
483D
490
422D
494D
S2
493D
487D
492D
S1
421D
491D
481D
446
410
440
A
N
S
O
L

Fig. 7

Fig. 8

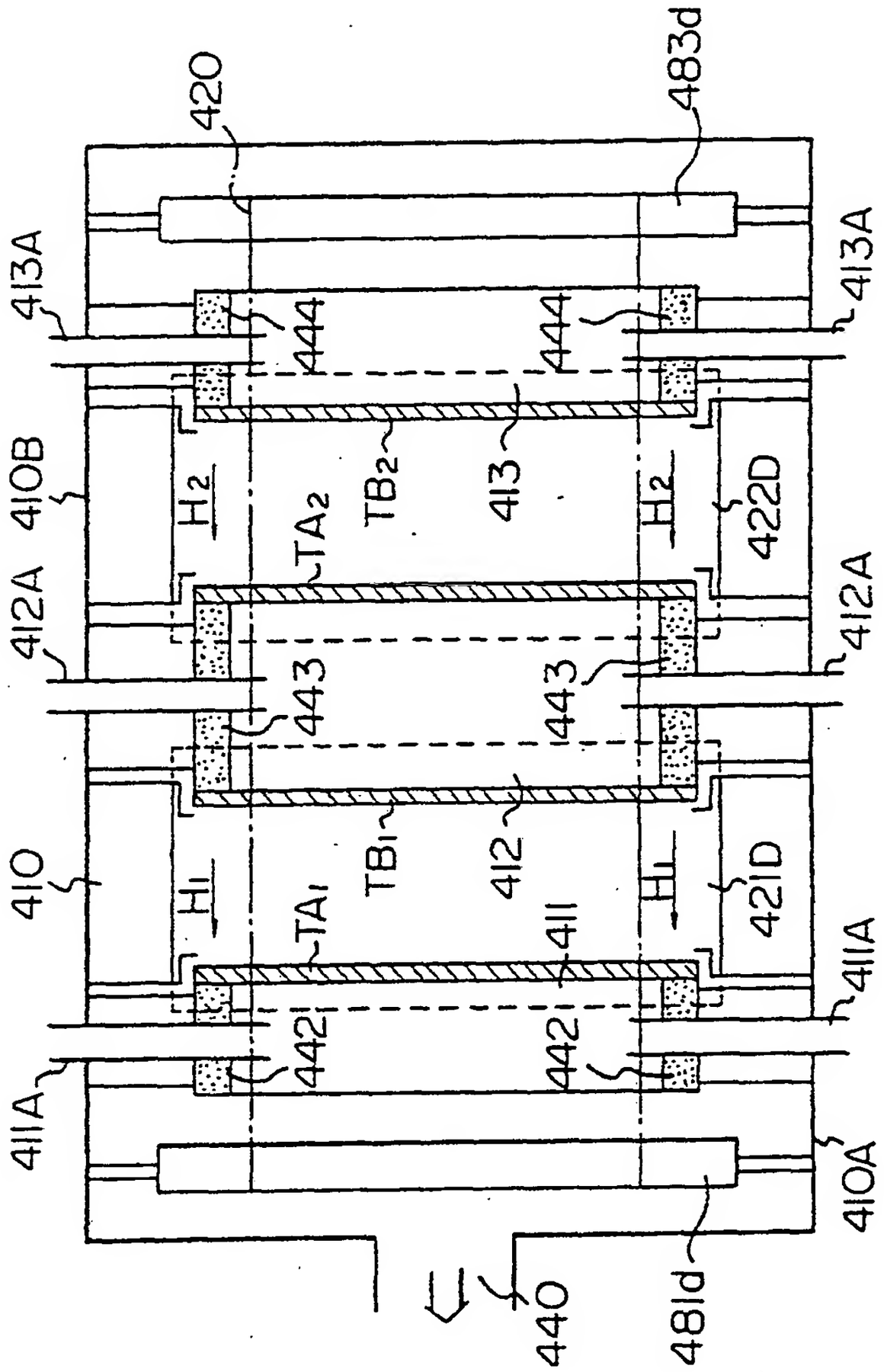

420
483d
413A
444
444
410B
412A
H2
TA2
TB2
413
H2
422D
443
443
410
H1
TA1
TB1
412
411
H1
421D
411A
442
442
410A
440
481d

Fig. 9

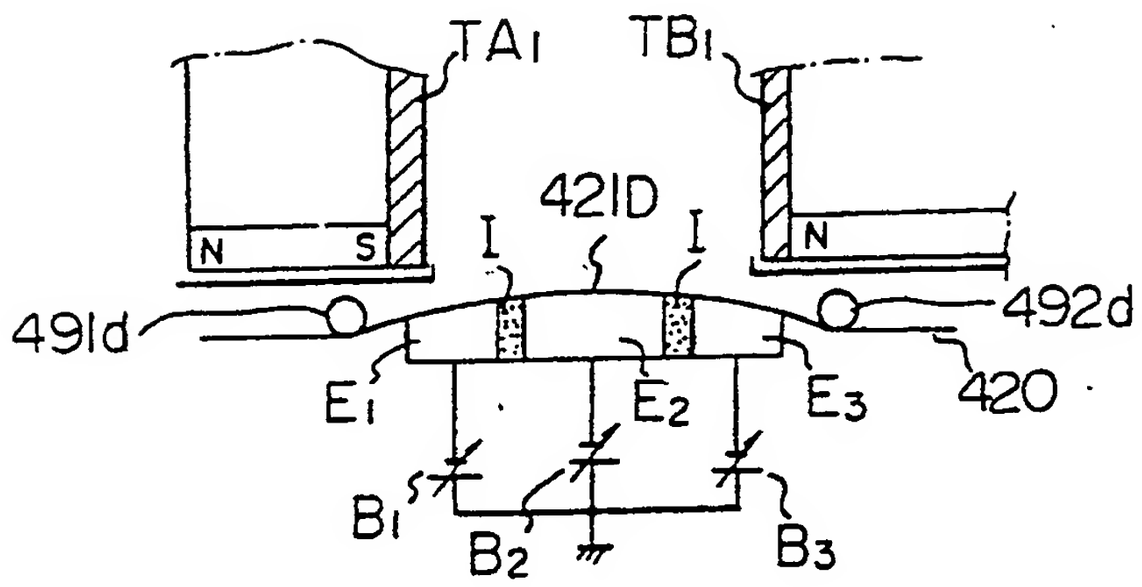

TA1
TB1
421D
I
I
N
S
N
491d
492d
420
E1
E2
E3
B1
B2
B3

Fig. 10

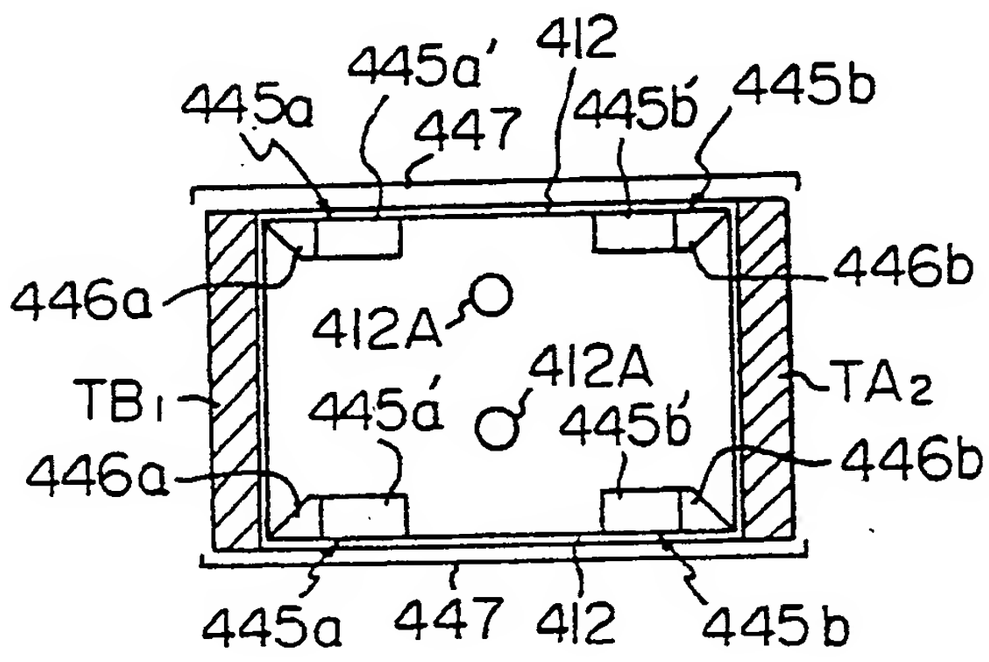

445a'
412
445a
447
445b'
445b
446a
446b
412A
412A
412A
TB1
445á
445b'
TA2
446a
446b
445a
447
412
445b

Fig. 11

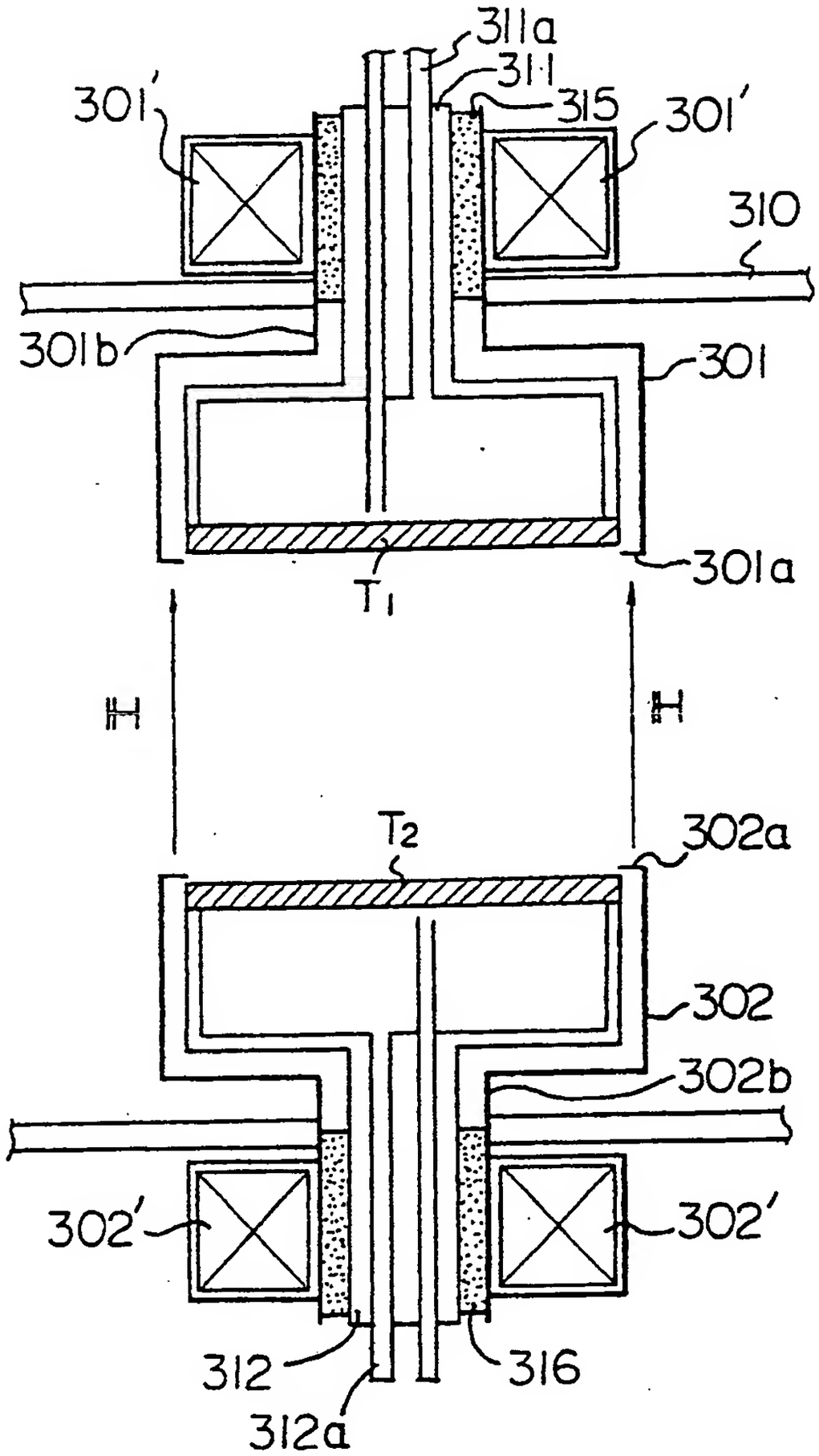

311a
311
315
301'
301'
310
301b
301
301a
T1
H
H
T2
302a
302
302b
302'
302'
312
316
312a

Fig. 12

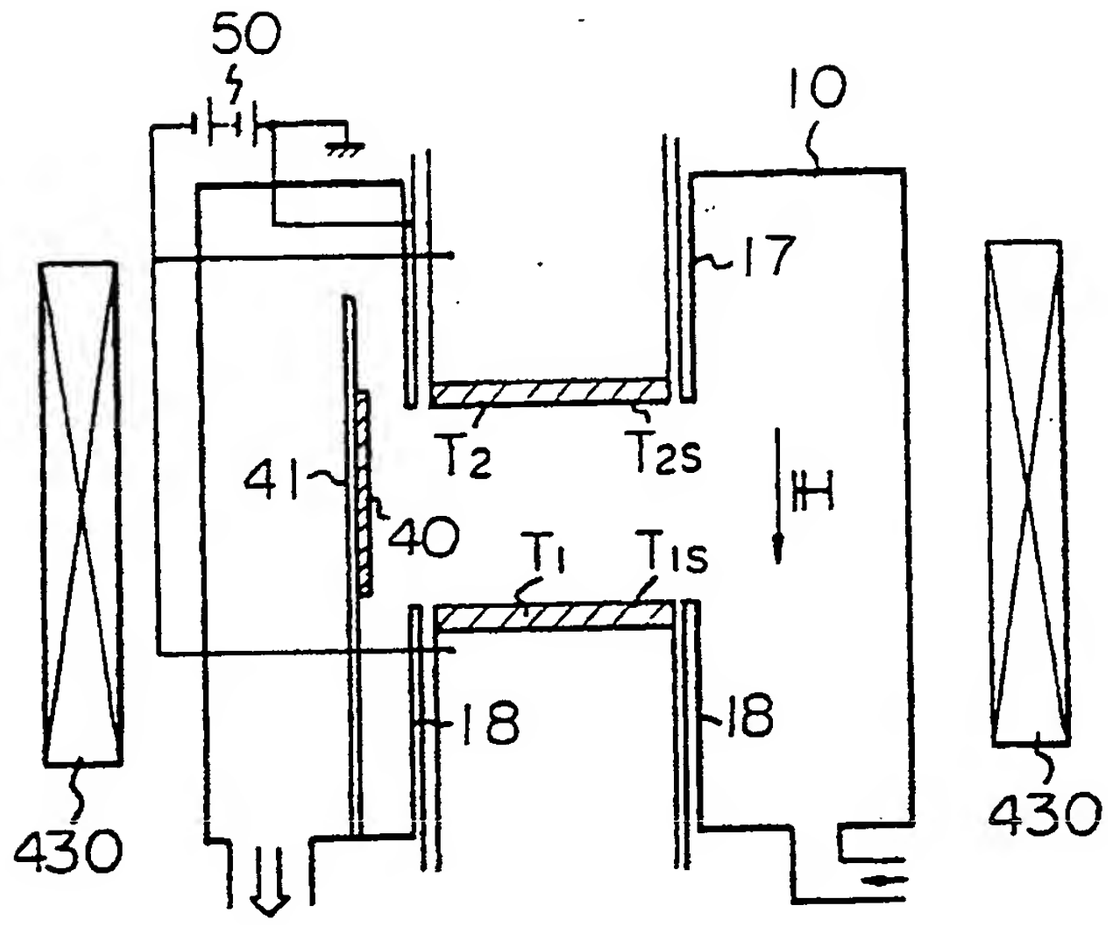


Fig. 14

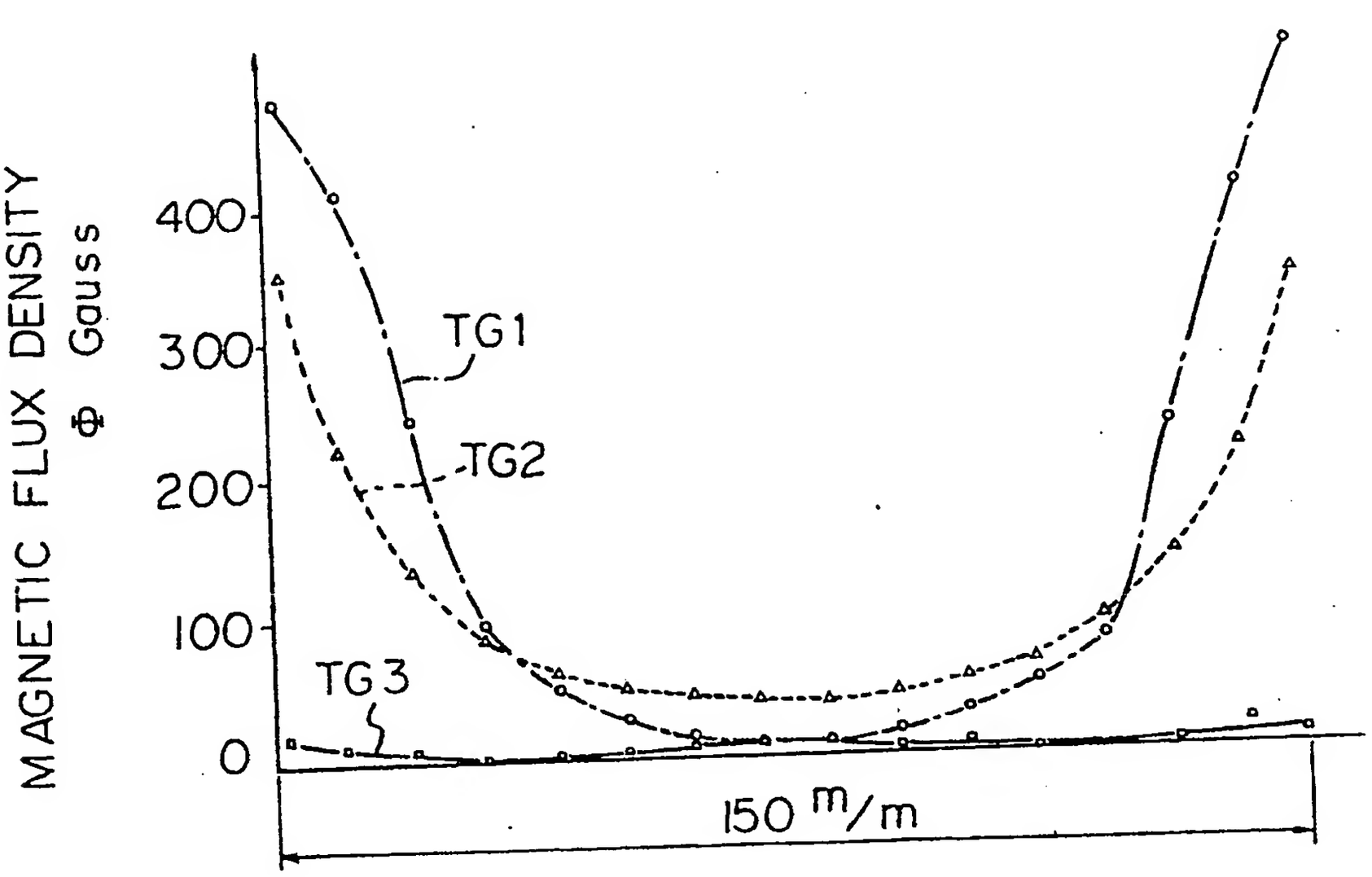

MAGNETIC FLUX DENSITY
Φ Gauss
400
300
200
100
0
TG1
TG2
TG3
150 m/m

Fig. 15